Scientific Ballooning Technologies Workshop
STO-2 Thermal Design and Analysis

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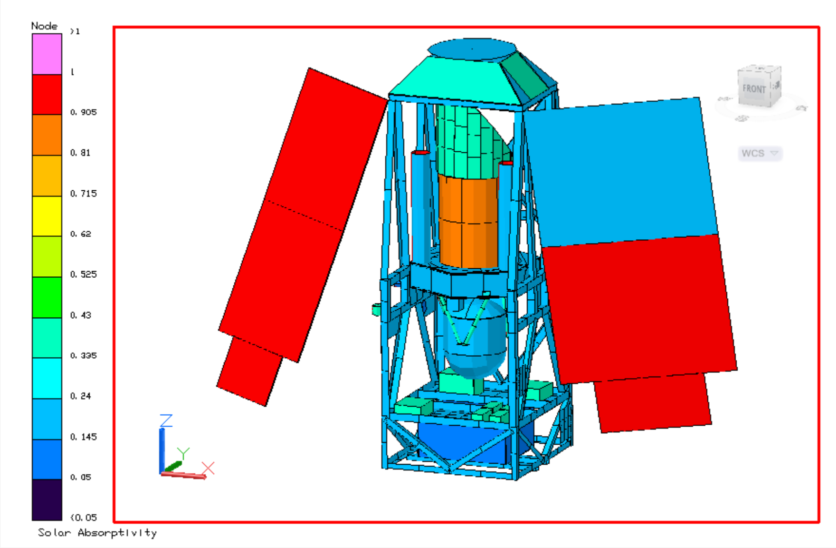
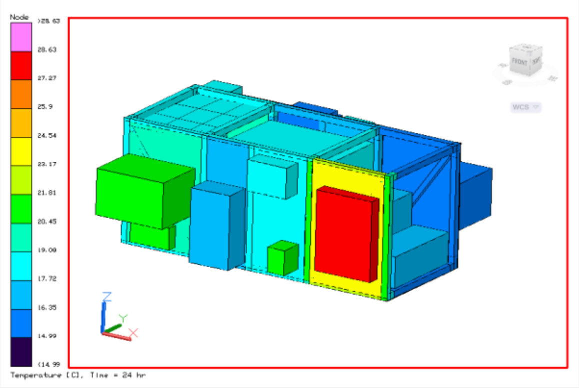
STO-2 Thermal Design and Analysis
Introduction

- The STO-2 experiment is planned to launch in the 2016-7 Antarctica campaign, rescheduled from the previous year.
  - The Applied Physics Laboratory of Johns Hopkins University provided the thermal design and analysis of the gondola and science instrument.
  - The SIP frame and components were modeled in detail by CSBF.
- The thermal design approach emphasizes passive thermal control methods such as radiator surface treatments and insulation over active methods such as heater control.
- The design approach is also cold-biased.
  - First, cooling systems are designed to produce acceptable maximum temperature predictions in worst-case hot scenarios
  - Then worst-case cold scenarios are evaluated to ensure minimum temperature predictions are acceptable, with design iteration continuing as needed.
- Design iterations involve updating the thermal model to produce new thermal analysis predictions.

STO-2 Thermal Design and Analysis
Thermal Analysis

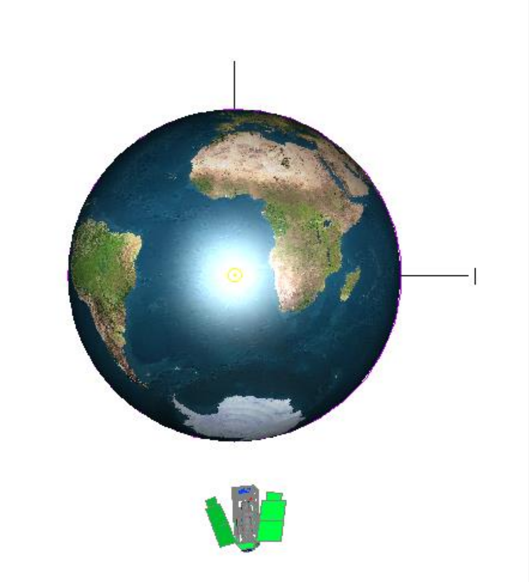
- The thermal model used for this program is updated from the vehicle model provided by Bruce Williams of the Applied Physics Laboratory.
  - The vehicle thermal model contained a coarse representation of the SIP.
  - The SIP has been added, taken from CSBF’s CREAM/BACCUS model and modified for STO-2.
- Thermal Desktop version 5.7 is used for this campaign.
  - Thermal Desktop includes SINDA/FLUINT, also from Cullimore & Ring.
  - Thermal Desktop is a geometric modeling tool calculating linear and radiative heat transfer interchange factors, nodal capacitance, environmental heating rates, among other thermal data.
  - SINDA/FLUINT solves a nodal network for steady state or transient temperatures and heat flows.
- The model has 835 nodes, including 355 nodes representing the SIP and surrounding structure.





STO-2 Thermal Design and Analysis
Thermal Analysis – Design Case Definition

- Environmental parameters vary w/ case bias, per the previous MRR presentation.
  - Solar constant: 441 to 443 Btu/h-ft^2
  - Albedo factor: 0.63 to 0.95
  - Earth IR flux: 49 to 79 Btu/h-ft^2
- During flight, Targets are either “GPS” or “LMC” nonstop.
  - Biasing cold and hot for each target leads to four design cases.
- In all design cases, the balloon floats at 70°S, 167°E, 19.75 nmi (~120,000 ft).
- Time profile: 6h on ground (with power on), 24 h in flight including ascent.
- Launch date and time vary with case bias.
  - Cold: January 31st, 2017, 12:01 A.M.
  - Hot: December 21st, 2016, noon



STO-2 Thermal Design and Analysis
Thermal Analysis – Model Results

- The model predictions below represent the peak transient temperature for the most severe design case for each listed component..

STO-2 Model Temperature Predictions (°C, peak transient): April 29, 2016

Subsystem	Component	Cold Case Margin	Cold Case Limit	Cold Case Predict	Hot Case Predict	Hot Case Limit	Hot Case Margin	Comments
TDRSS/COMM1	Flight Computer	35	-40	-5	29	90	61	baseplate model predict compared to internal comp. limit
	Terminal Box	48	-55	-7	27	55	28	
	System Stack	49	-55	-6	27	70	43	
	Backup Stack	50	-55	-5	29	70	41	
	TDRSS Transceiver	33	-40	-7	31	70	39	
	PCM Encoder	37	-40	-3	29	70	41	
Iridium/COMM2	Flight Computer	40	-40	0	31	90	59	
	Backup Nav. Box	37	-40	-3	28	70	42	
	Terminal Box	48	-55	-7	27	55	28	
	System Stack	51	-55	-4	31	70	39	
	PCM Encoder	38	-40	-2	31	70	39	
	LOS Box	27	-20	7	40	50	10	baseplate model predict compared to internal comp. limit
Power Control System	PCU Box	36	-40	-4	28	70	42	
	Charge Controllers	35	-40	-5	27	80	53	
	Battery Pack	47	-55	-8	26	57	31	

- The model predictions show comfortable temperature margins for all components.
- These temperature predictions are in good general agreement with those found in the previous MRR in August, 2015.